U.S. DEPARTMENT OF ENERGY
SOLAR DECATHLON
2011

Do Photovoltaic Energy Systems Increase Home Values?

Ben Hoen
Lawrence Berkeley National Laboratory
October 1st, 2011

Lawrence Berkeley National Laboratory

Member of the National Laboratory System supported by the U.S. Department of Energy through its Office of Science.

Located in Berkeley, California

Founded in 1931 by Ernest Orlando Lawrence

Annual Budget of $811 Million

4,200 Employees and 800 University Students

11 Nobel Laureates

24 Divisions and Departments

"To achieve our energy and climate goals, we need a strong and sustained commitment to research and development. These investments are needed for our country's future economic prosperity, energy security, and environmental sustainability"

Steven Chu, Secretary of Energy, January 21, 2010

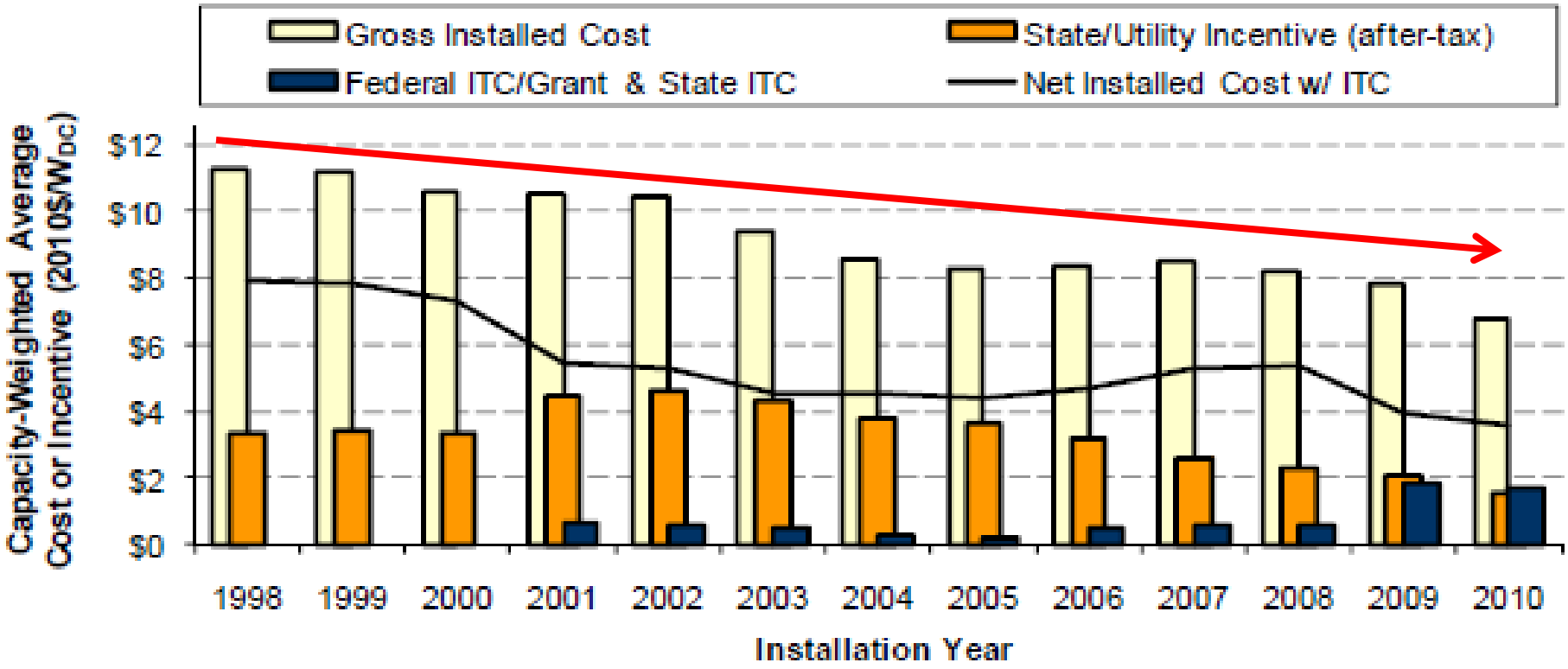
Do Photovoltaic Energy Systems Increase Home Values?

- **Residential PV Market Summary**
- There Are Still Significant Market Barriers
- Previous Literature On Impacts To Home Values
- LBNL Research Findings
- Where Do Stakeholders Go From Here?
- Questions?

What is a Watt?

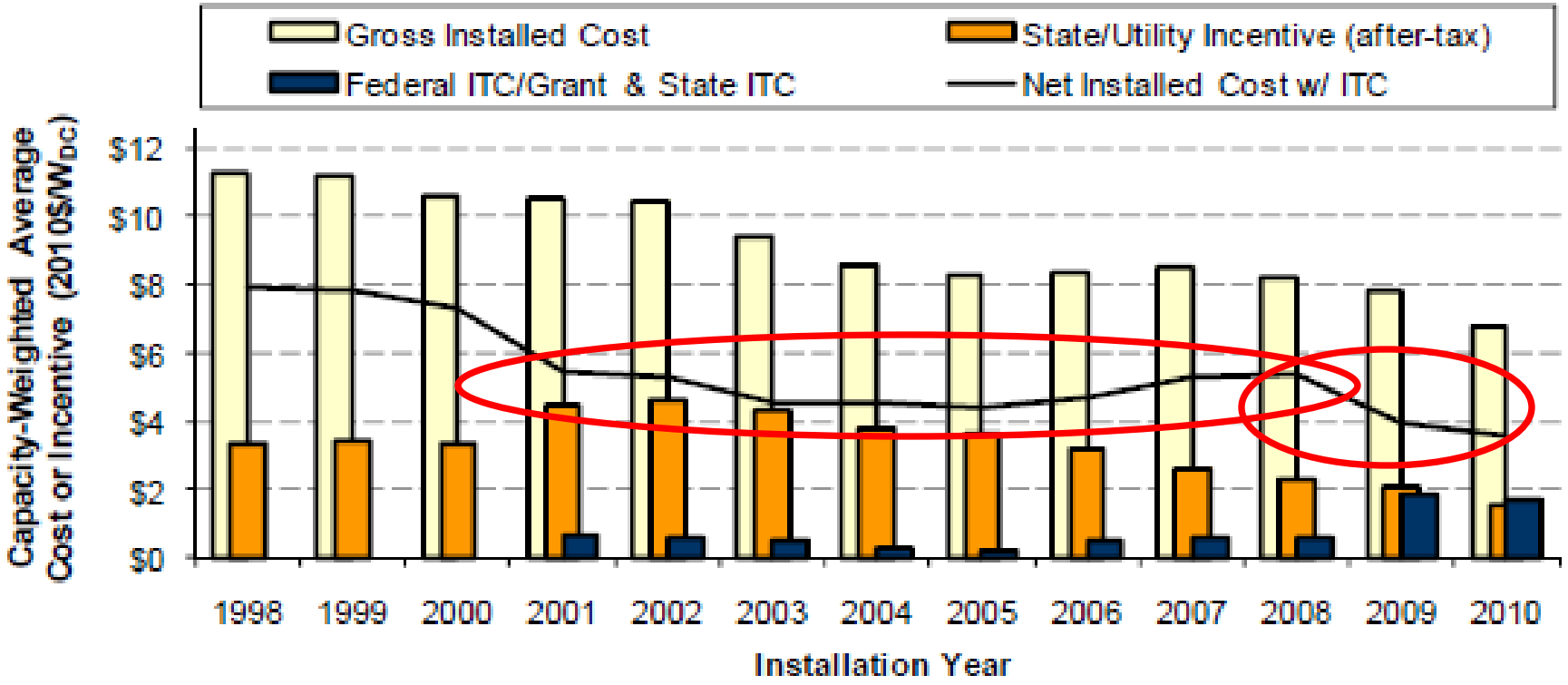
- A Watt is a unit of electrical energy (or “power”).
- PV systems are rated based on the amount of Watts they can produce under perfect conditions.
- The higher the Watt rating, the more energy a PV system will produce.
- PV systems are priced in dollars per Watt or $/Watt

Average Gross Installed Costs For Residential PV Have Declined Through 2010



Source: Lawrence Berkeley National Laboratory (2011) Tracking the Sun III

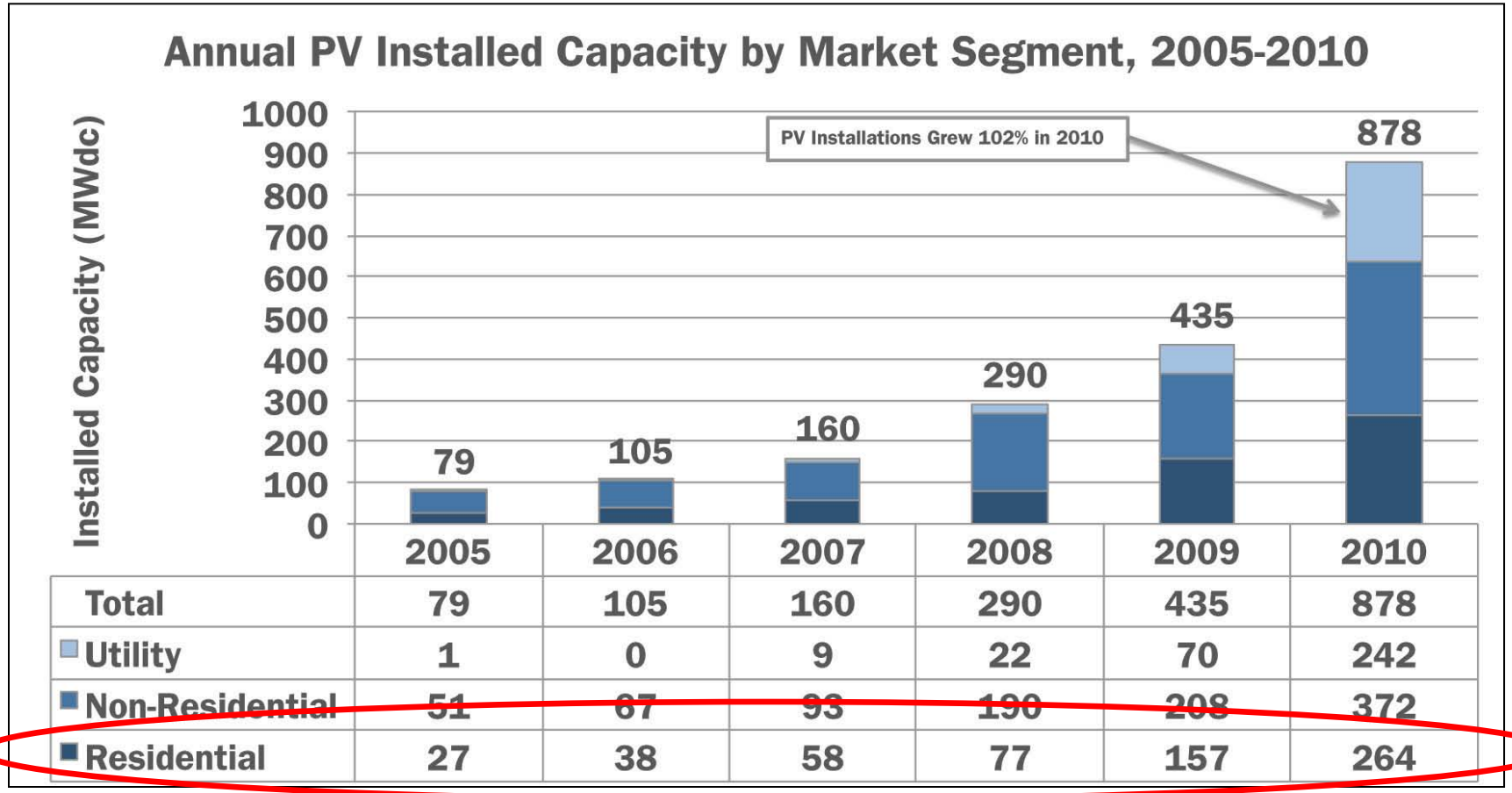
Average Net Installed Costs Have Remained Fairly Flat Through 2008 Near $5/Watt Yet Declined Sharply Thru 2010 To Near $4/Watt



Net Installed Cost = Average cost of installing PV, after deducting available state/federal incentives

Source: Lawrence Berkeley National Laboratory (2011) Tracking the Sun III

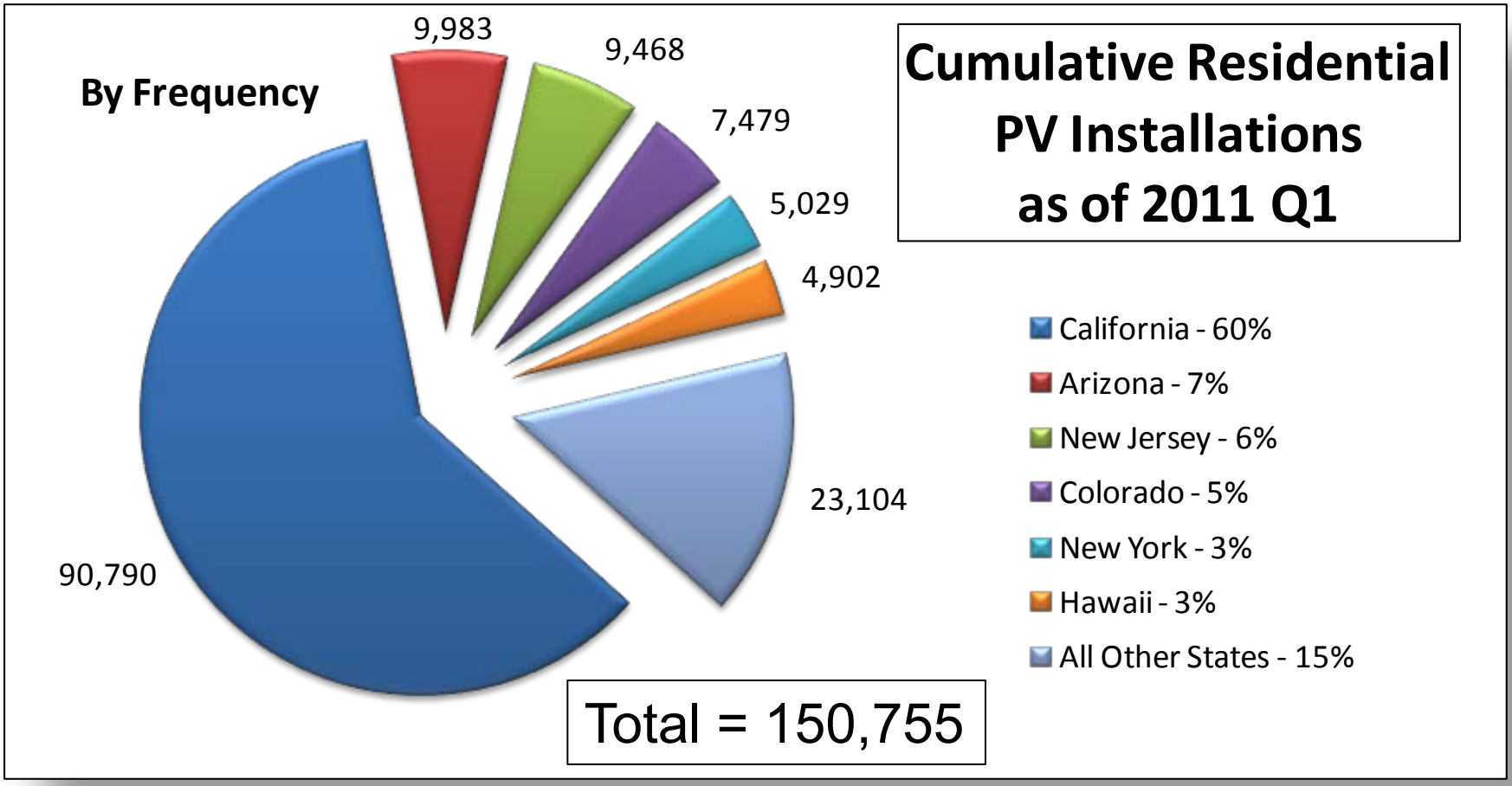
Solar PV Installations Have Been Increasing Dramatically In The US, Including Residential



	2005	2006	2007	2008	2009	2010
Total	79	105	160	290	435	878
Utility	1	0	9	22	70	242
Non-Residential	51	67	93	190	208	372
Residential	27	38	58	77	157	264

Source: Solar Energy Industries Association, U.S. Solar Market Insight™: 2010 Year-In-Review

Through 2011 There Are 150,000 Residential Installations. Mostly In California, Yet Other States Are Growing



Source: Solar Energy Industries Association

Do Photovoltaic Energy Systems Increase Home Values?

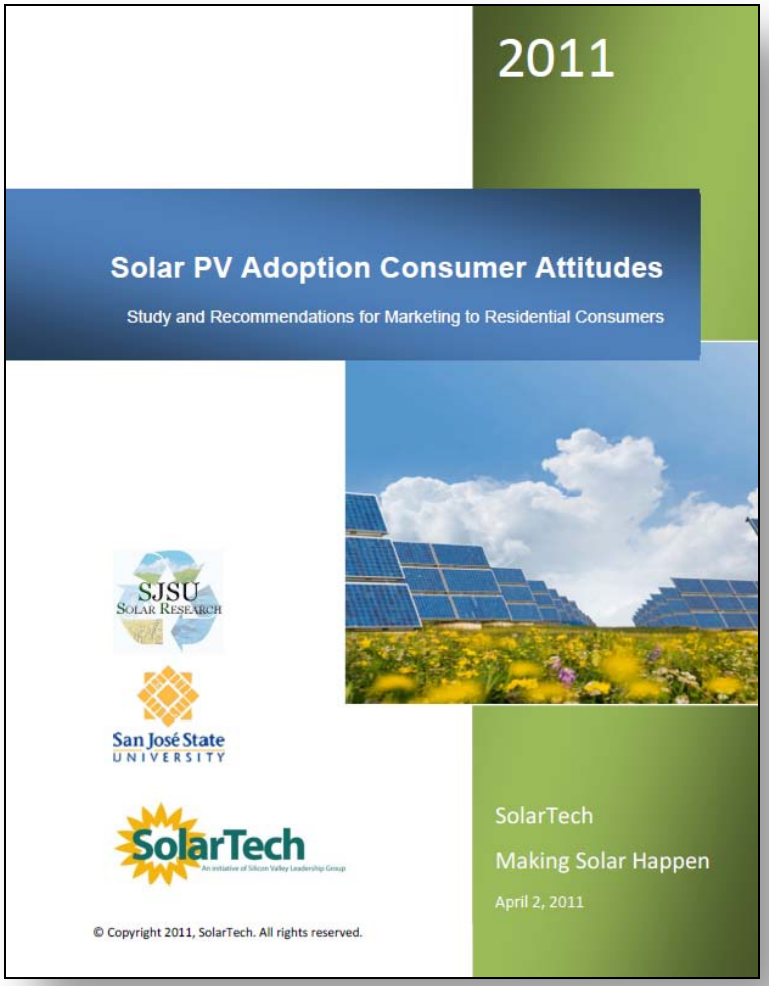
- Residential PV Market Summary
- **There Are Still Significant Market Barriers**
- Previous Literature On Impacts To Home Values
- LBNL Research Findings
- Where Do Stakeholders Go From Here?
- Questions?

Barriers To PV Adoption Are Multi-Faceted

- Lack of government policy
- Lack of consumer awareness
- High cost of solar
- Difficulty overcoming established energy systems
- Inadequate financing options
- Failure to account for all costs and benefits of energy choices
- Inadequate workforce skills and training
- Lack of adequate codes, standards, and interconnection and net-metering guidelines
- Poor perception by public of renewable energy system aesthetics
- Lack of stakeholder/community participation in energy choices

Source: National Renewable Energy Lab, 2006

There Is A Perception That PV Systems Are Expensive



Survey of residents of Santa Clara County, CA

- Santa Clara has 15 MW of PV installed (~3,000 systems), and therefore a high likelihood of PV familiarity
- 82% perceived PV as “expensive”
- 11% perceived PV as “affordable”

Source: www.SolarTech.org

Homeowners/Builders May Be Hesitant To Invest Given Uncertain Resale Values

The Washington Post

Back to previous page

Is green good for home resale value?

By Kenneth R. Harney, Published: August 26

Home energy efficiency and sustainability have been major policy priorities for the Obama administration, but lurking in the background are two pesky questions: Beyond the documentable savings on utilities bills, do such steps add to the resale value of a home? And do they make it easier to sell your property?

Housing groups and housing officials say definitive data covering multiple regions of the country are scarce. But some localized research projects in Oregon

Although Change is Proposed, Appraisers Have Been Slow To Account For Energy Features In Their Residential Valuations

The New York Times

August 25, 2011

Strange Bedfellows Back Bill Using Mortgages to Spur Energy Retrofits

By JASON PLAUTZ of

A Senate bill that would allow energy-saving retrofits to be factors in mortgage underwriting has quickly attracted a diverse set of enthusiastic supporters that range from the conservative U.S. Chamber of Commerce to the liberal Center for American Progress.

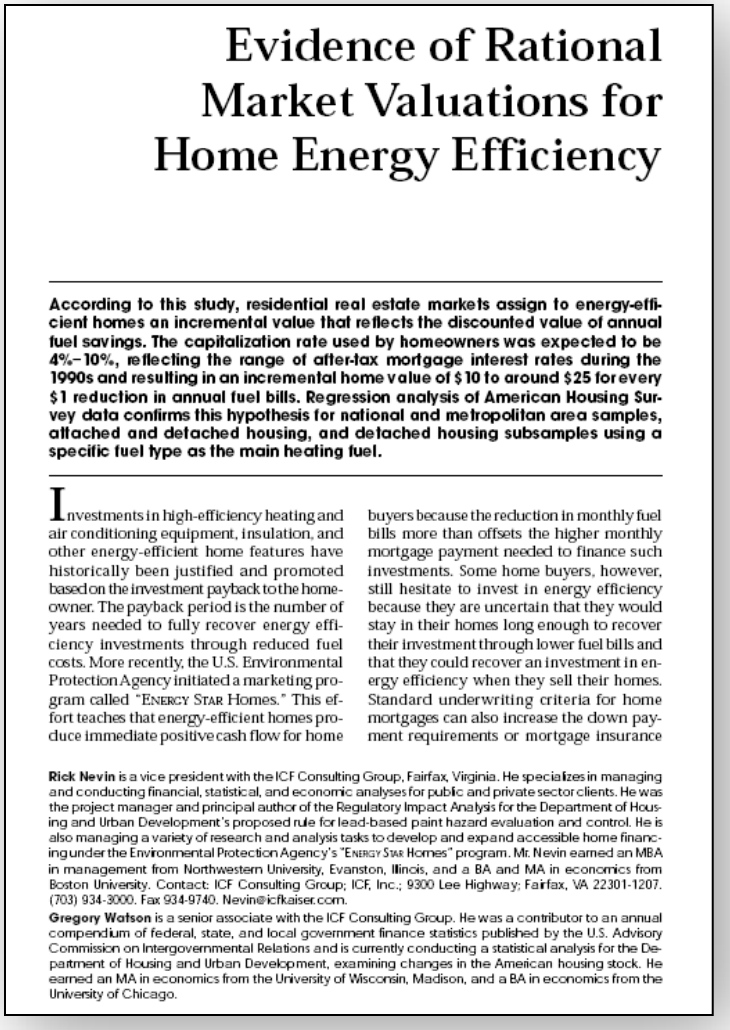
The "Sensible Accounting to Value Energy Act," or SAVE Act, which is expected to be introduced this fall by Sen. Michael Bennet (D-Colo.), would require federal loan agencies to include projected energy costs when financing a house, essentially offering better mortgage values on properties that are more energy efficient.

Do Photovoltaic Energy Systems Increase Home Values?

- Residential PV Market Summary
- There Are Still Significant Market Barriers
- **Previous Literature On Impacts To Home Values**
- LBNL Research Findings
- Where Do Stakeholders Go From Here?
- Questions?

Nevin & Watson (1998)

"Evidence of Rational Market Values for Home Energy Efficiency"



Evidence of Rational Market Valuations for Home Energy Efficiency

According to this study, residential real estate markets assign to energy-efficient homes an incremental value that reflects the discounted value of annual fuel savings. The capitalization rate used by homeowners was expected to be 4%–10%, reflecting the range of after-tax mortgage interest rates during the 1990s and resulting in an incremental home value of $10 to around $25 for every $1 reduction in annual fuel bills. Regression analysis of American Housing Survey data confirms this hypothesis for national and metropolitan area samples, attached and detached housing, and detached housing subsamples using a specific fuel type as the main heating fuel.

Investments in high-efficiency heating and air conditioning equipment, insulation, and other energy-efficient home features have historically been justified and promoted based on the investment payback to the homeowner. The payback period is the number of years needed to fully recover energy efficiency investments through reduced fuel costs. More recently, the U.S. Environmental Protection Agency initiated a marketing program called "Energy Star Homes." This effort teaches that energy-efficient homes produce immediate positive cash flow for home buyers because the reduction in monthly fuel bills more than offsets the higher monthly mortgage payment needed to finance such investments. Some home buyers, however, still hesitate to invest in energy efficiency because they are uncertain that they would stay in their homes long enough to recover their investment through lower fuel bills and that they could recover an investment in energy efficiency when they sell their homes. Standard underwriting criteria for home mortgages can also increase the down payment requirements or mortgage insurance

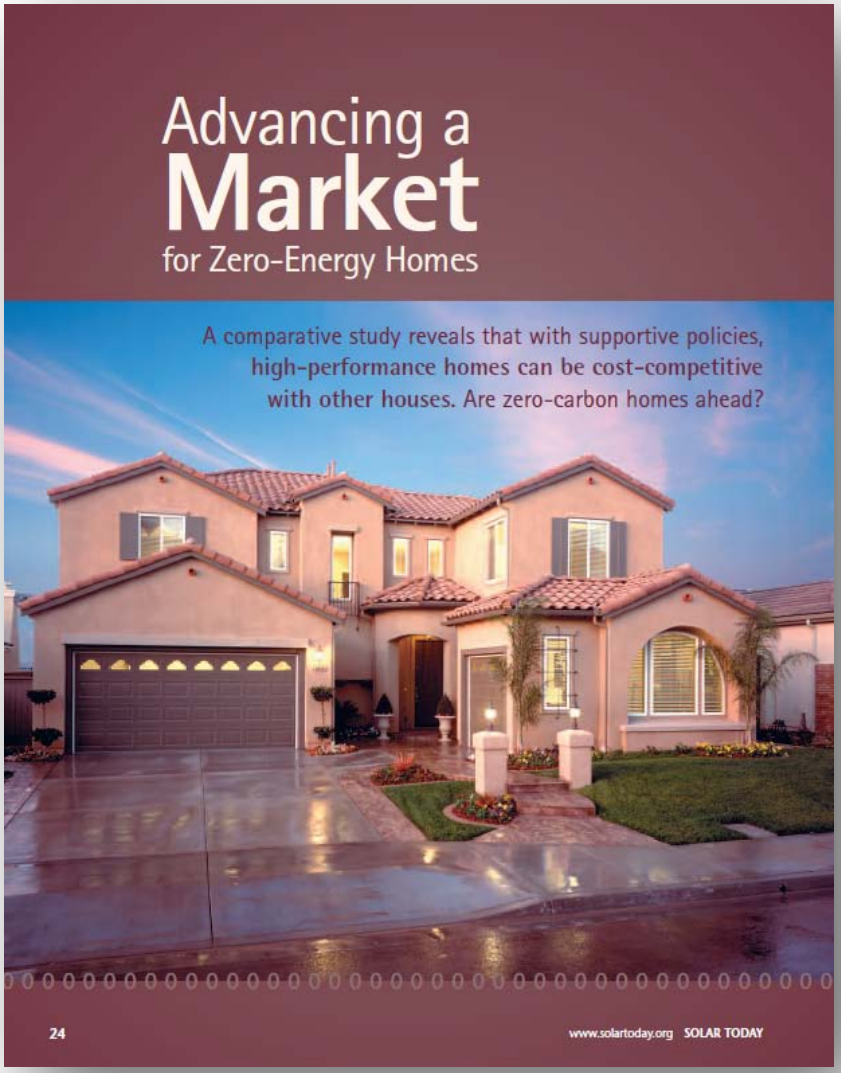
Rick Nevin is a vice president with the ICF Consulting Group, Fairfax, Virginia. He specializes in managing and conducting financial, statistical, and economic analyses for public and private sector clients. He was the project manager and principal author of the Regulatory Impact Analysis for the Department of Housing and Urban Development's proposed rule for lead-based paint hazard evaluation and control. He is also managing a variety of research and analysis tasks to develop and expand accessible home financing under the Environmental Protection Agency's "Energy Star Homes" program. Mr. Nevin earned an MBA in management from Northwestern University, Evanston, Illinois, and a BA and MA in economics from Boston University. Contact: ICF Consulting Group; ICF, Inc.; 9300 Lee Highway; Fairfax, VA 22301-1207. (703) 934-3000. Fax 934-9740. Nevin@icfkaiser.com.

Gregory Watson is a senior associate with the ICF Consulting Group. He was a contributor to an annual compendium of federal, state, and local government finance statistics published by the U.S. Advisory Commission on Intergovernmental Relations and is currently conducting a statistical analysis for the Department of Housing and Urban Development, examining changes in the American housing stock. He earned an MA in economics from the University of Wisconsin, Madison, and a BA in economics from the University of Chicago.

- Multiple models with sample sizes ranging from 600 to 46,000 across various parts of the country
- Concluded 20:1 reasonable average for sales price to energy savings ratio given a 5% after tax mortgage rate
- This implies for every $1 saved via energy efficiency the home's value is increased by $20

Farhar and Coburn (2008)

"A New Market Paradigm for Zero-Energy Homes: A Comparative Case Study"

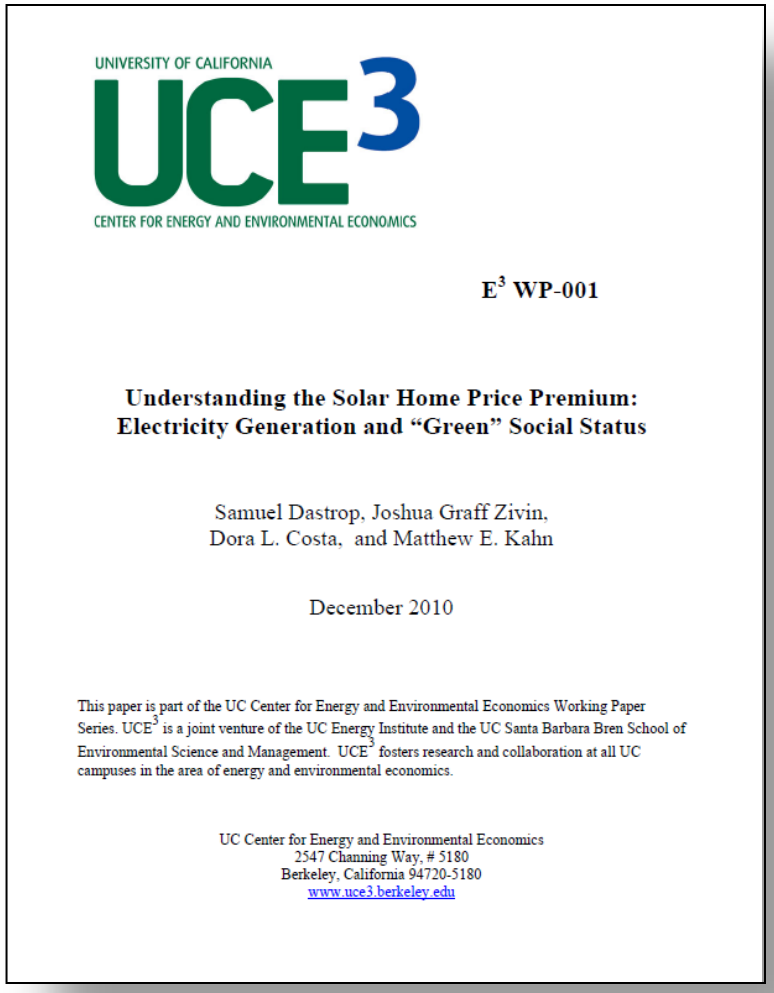


Gains in Property Values and Length of Ownership for HPHs and Comparison Homes
(as of 2/7/05)

Variable	High-Performance Homes (n=15)	Comparison Homes (n=12)
Original price (mean)	$556,344	$598,028
Length of ownership (mean)	22.5 mos.	28.1 mos.
Resale price (mean)	$862,853	$862,590
Mean $ gain in property value	$306,510	$262,968
Mean percent gain in property value	55.4%	44.7%
Mean $ gain per month owned	$14,492	$9,301

Dastrop, Ziven, Costa & Kahn (2010)

"Understanding the Solar Home Price Premium"



UNIVERSITY OF CALIFORNIA
UCE3
CENTER FOR ENERGY AND ENVIRONMENTAL ECONOMICS

E³ WP-001

Understanding the Solar Home Price Premium: Electricity Generation and "Green" Social Status

Samuel Dastrop, Joshua Graff Zivin,
Dora L. Costa, and Matthew E. Kahn

December 2010

This paper is part of the UC Center for Energy and Environmental Economics Working Paper Series. UCE³ is a joint venture of the UC Energy Institute and the UC Santa Barbara Bren School of Environmental Science and Management. UCE³ fosters research and collaboration at all UC campuses in the area of energy and environmental economics.

UC Center for Energy and Environmental Economics
2547 Channing Way, # 5180
Berkeley, California 94720-5180
www.uce3.berkeley.edu

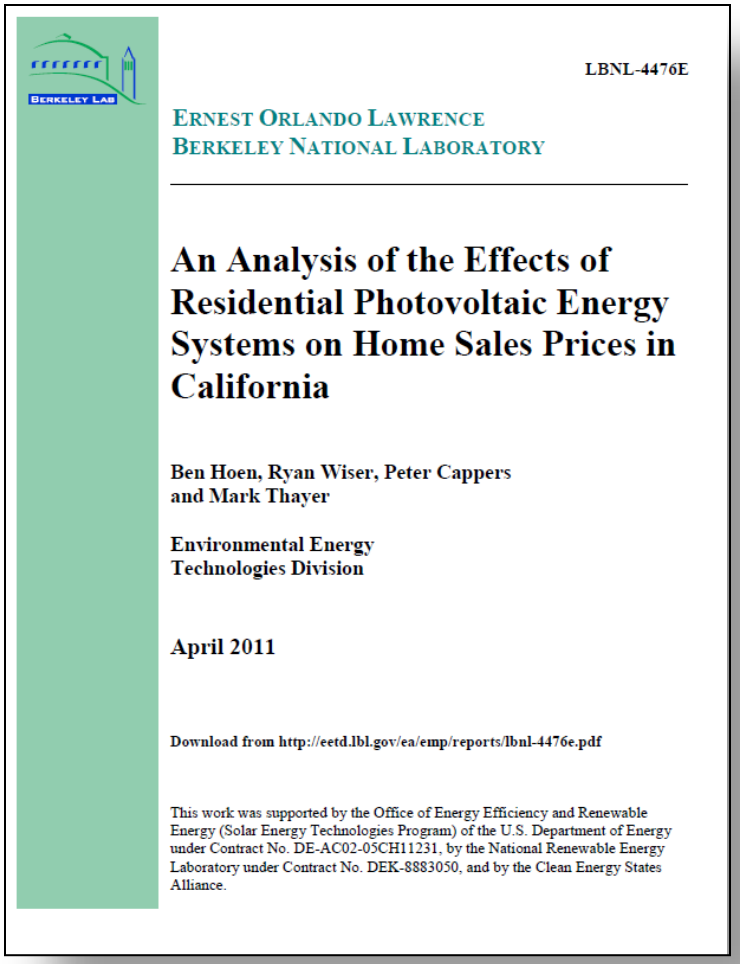
- Investigated 279 PV homes that sold in Greater San Diego
- Found significant difference between PV and non-PV sales prices
- Premiums of approximately 3.5% for PV homes found
- Equates to approximately $4.40 per installed watt (DC)

Do Photovoltaic Energy Systems Increase Home Values?

- Residential PV Market Summary
- There Are Still Significant Market Barriers
- Previous Literature On Impacts To Home Values
- **LBNL Research Findings**
- Where Do Stakeholders Go From Here?
- Questions?

Hoen, Wiser, Cappers & Thayer (2011)

"An Analysis of the Effects of Residential Photovoltaic Energy Systems on Home Sales Prices in California"



LBNL-4476E

ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY

An Analysis of the Effects of Residential Photovoltaic Energy Systems on Home Sales Prices in California

Ben Hoen, Ryan Wiser, Peter Cappers and Mark Thayer

Environmental Energy Technologies Division

April 2011

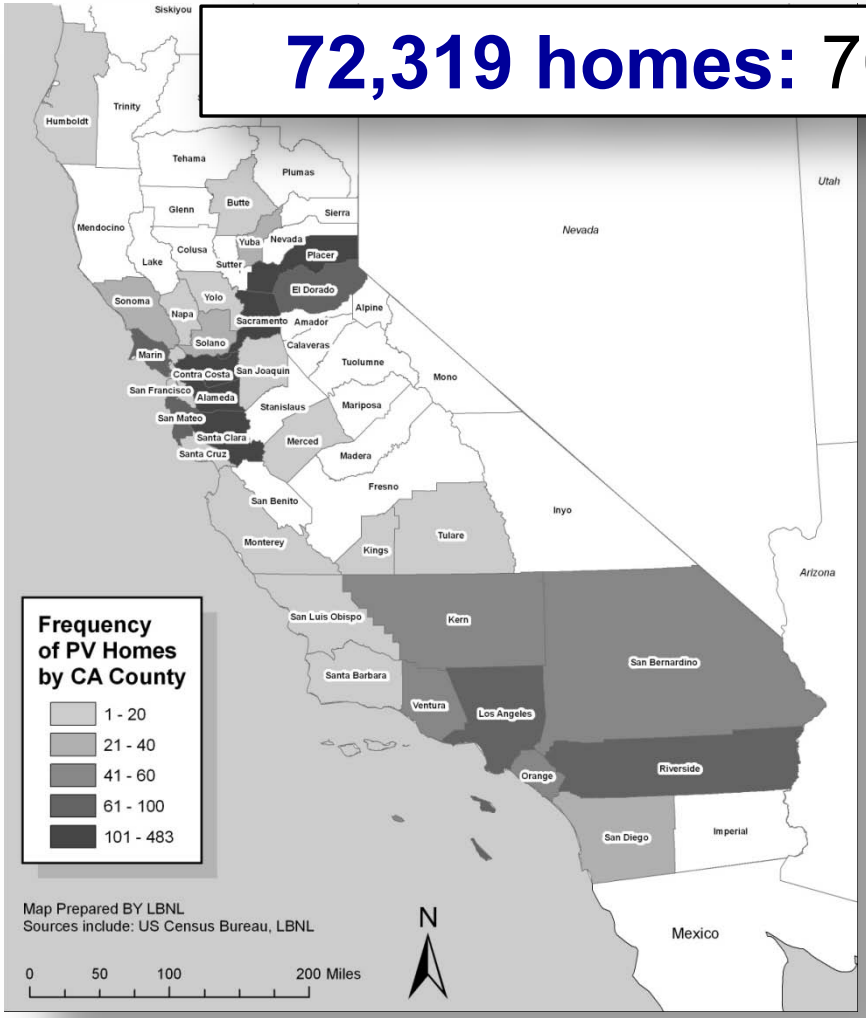
Download from http://eetd.lbl.gov/ea/emp/reports/lbnl-4476e.pdf

This work was supported by the Office of Energy Efficiency and Renewable Energy (Solar Energy Technologies Program) of the U.S. Department of Energy under Contract No. DE-AC02-05CH11231, by the National Renewable Energy Laboratory under Contract No. DEK-8883050, and by the Clean Energy States Alliance.

- Build on available literature
- Investigate selling prices of homes with PV relative to comparable non-PV homes
- Concentrate on California PV but across multiple counties
- Use a variety of different tests to determine premiums

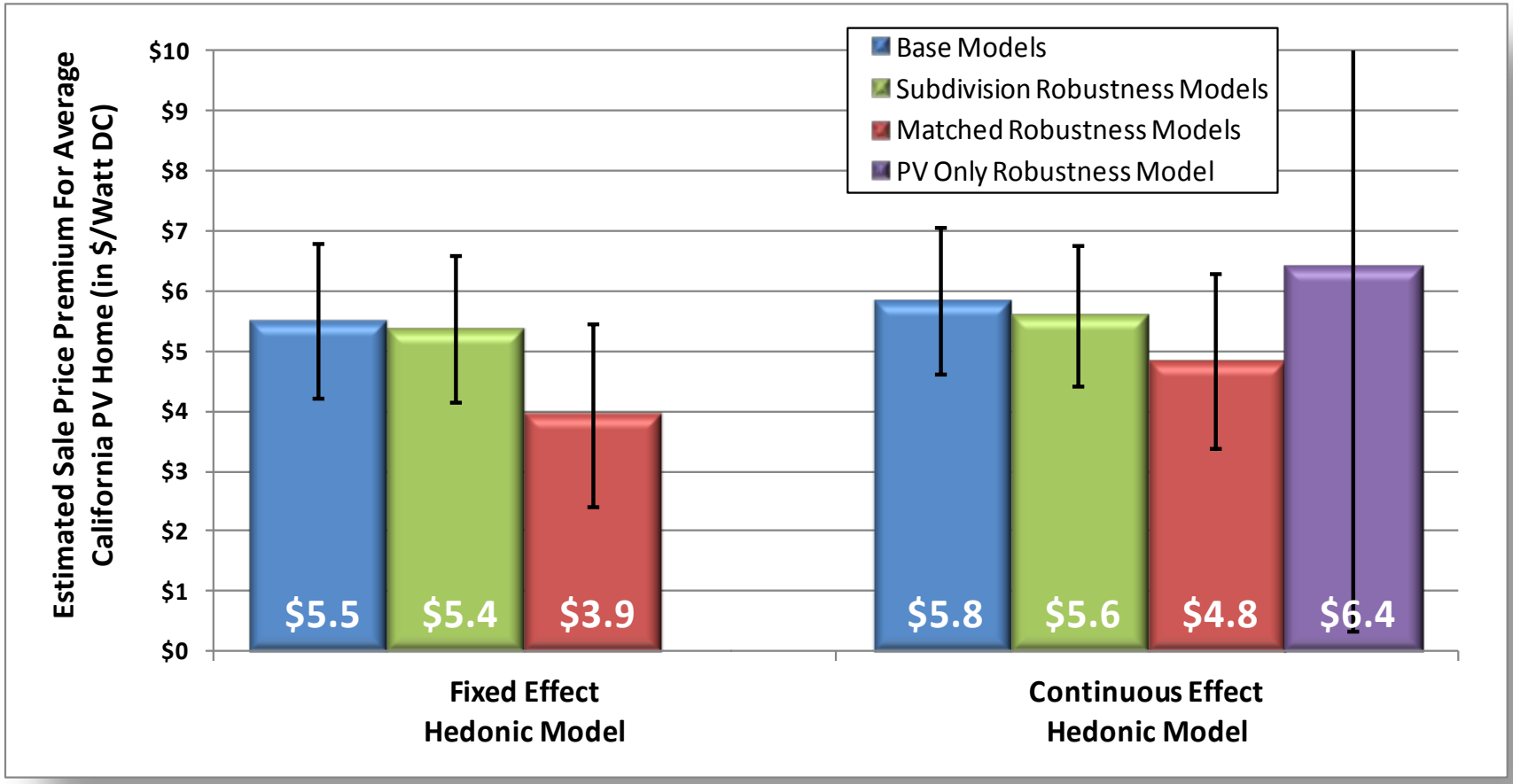
PV Sales Data Are Well Arrayed Across California, Among Home Types, Utility Service Areas, And Years

72,319 homes: 70,425 non-PV; 1,894 PV

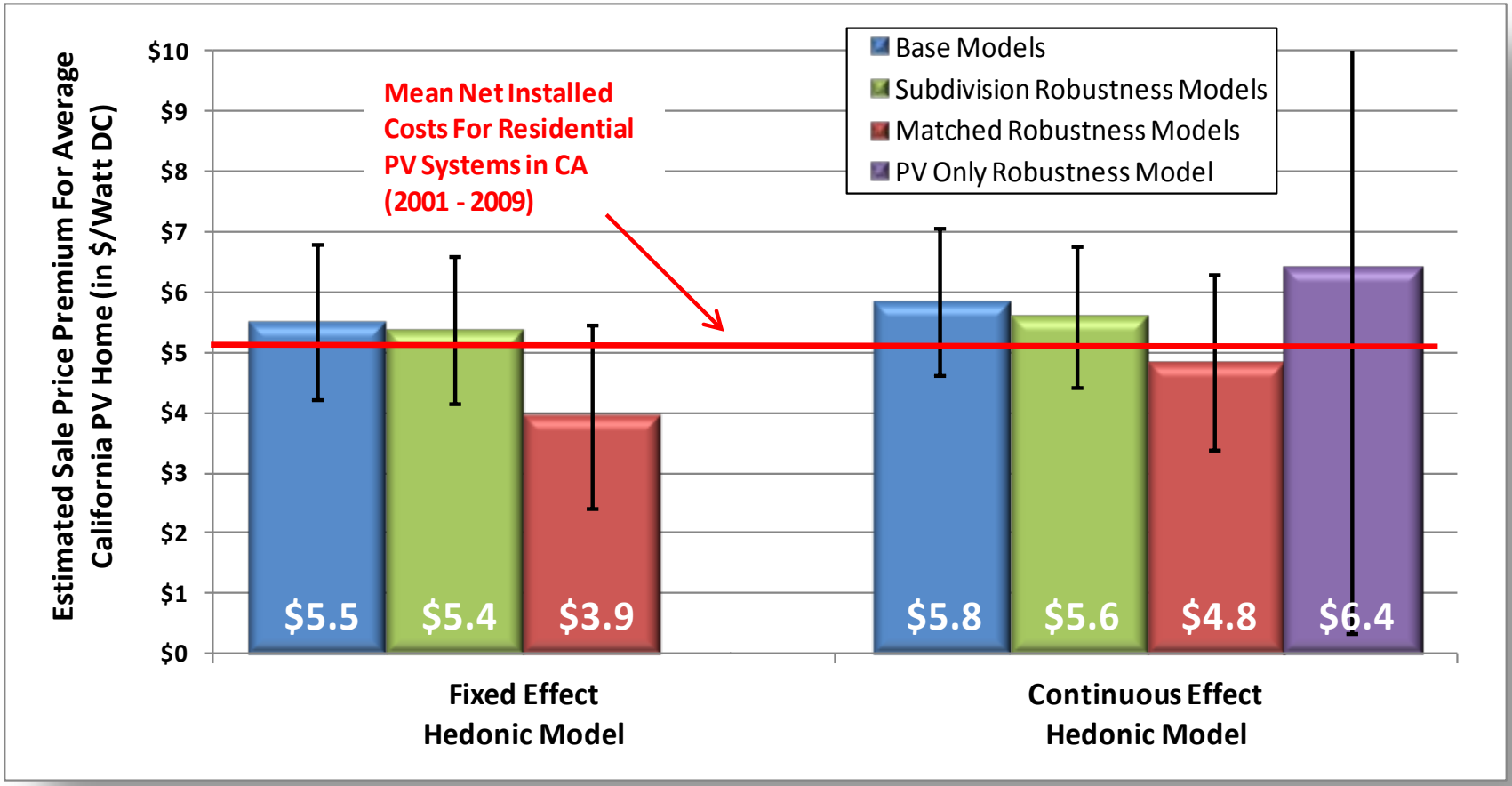


- **31 Counties**
- **4 Different Utility Service Areas:** PG&E, SCE, SDG&E, SMUD
- **11 Years:** 1999-2009
- **50% New Homes**
  50% Existing Homes

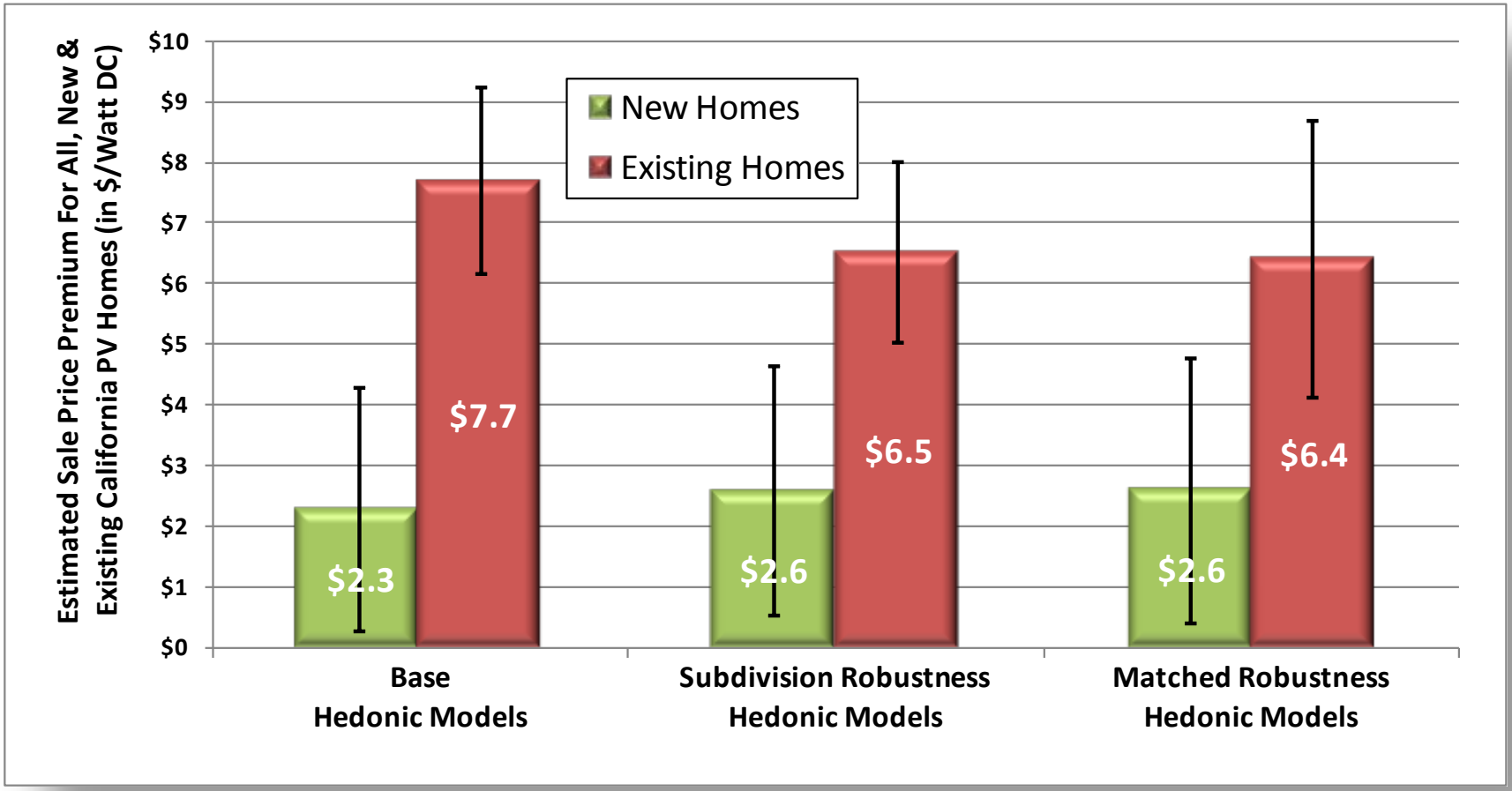
Estimated $/Watt (DC, STC) Premiums For The Full Sample Are Between $3.9 and $6.4



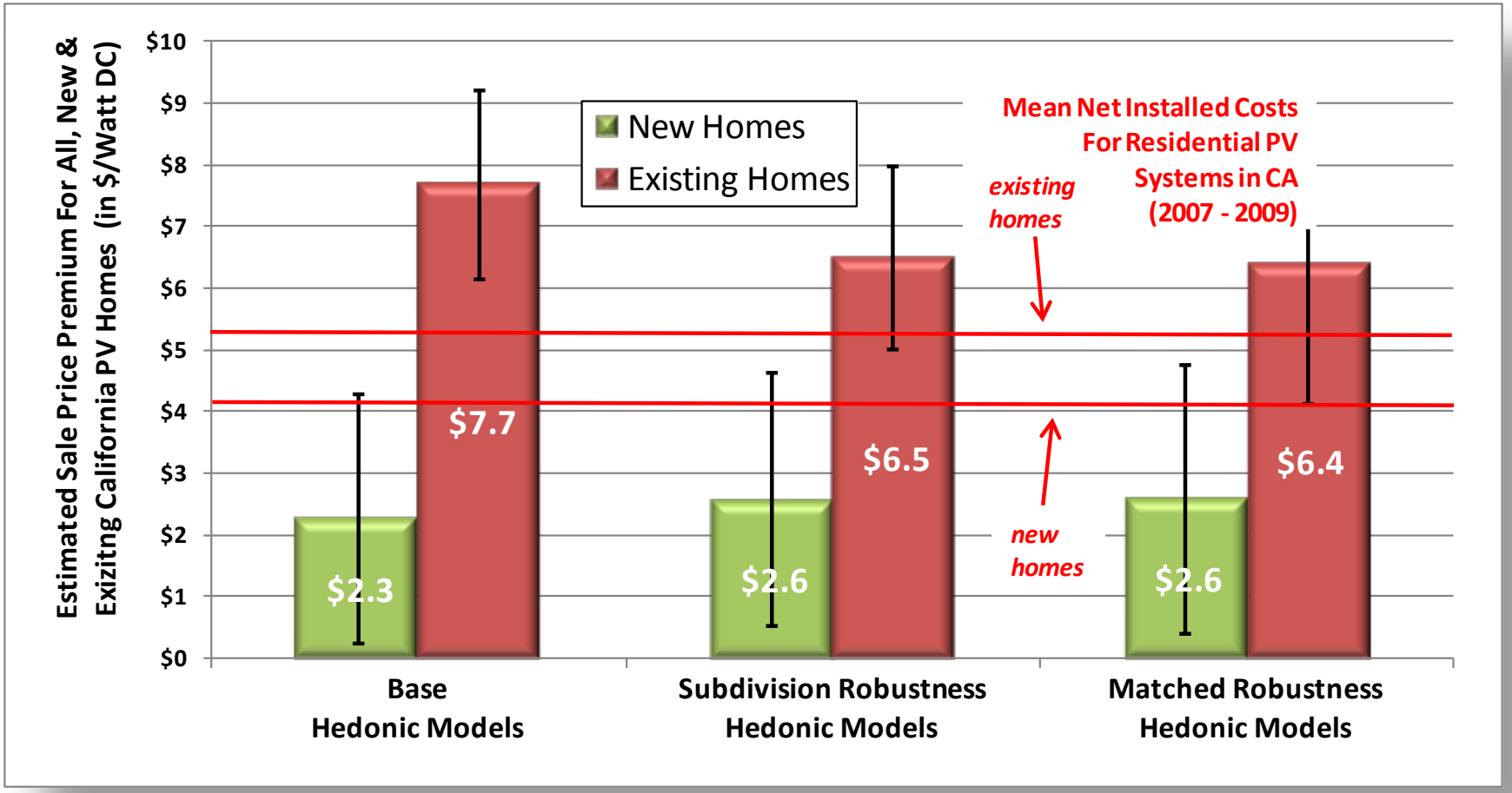
Buyers And Sellers Might Be Using Net Installed Costs As A Price Signal



Large Differences In Premiums Were Found Between New and Existing Homes



Differences Might Be Partly Explained By Disparity In Net Installed Costs



Disparities Might Be Explained By Other Factors Besides Net Installed Cost

New Homes		Existing Homes
Increased sales velocity?	←→	Highest price?
Sales agent less familiarity with PV?	←→	Homeowner more familiarity with PV?
Group PV with other features?	←→	Differentiate PV from other features?
Less expensive homes = less discretionary income?	←→	More expensive homes = more discretionary income?

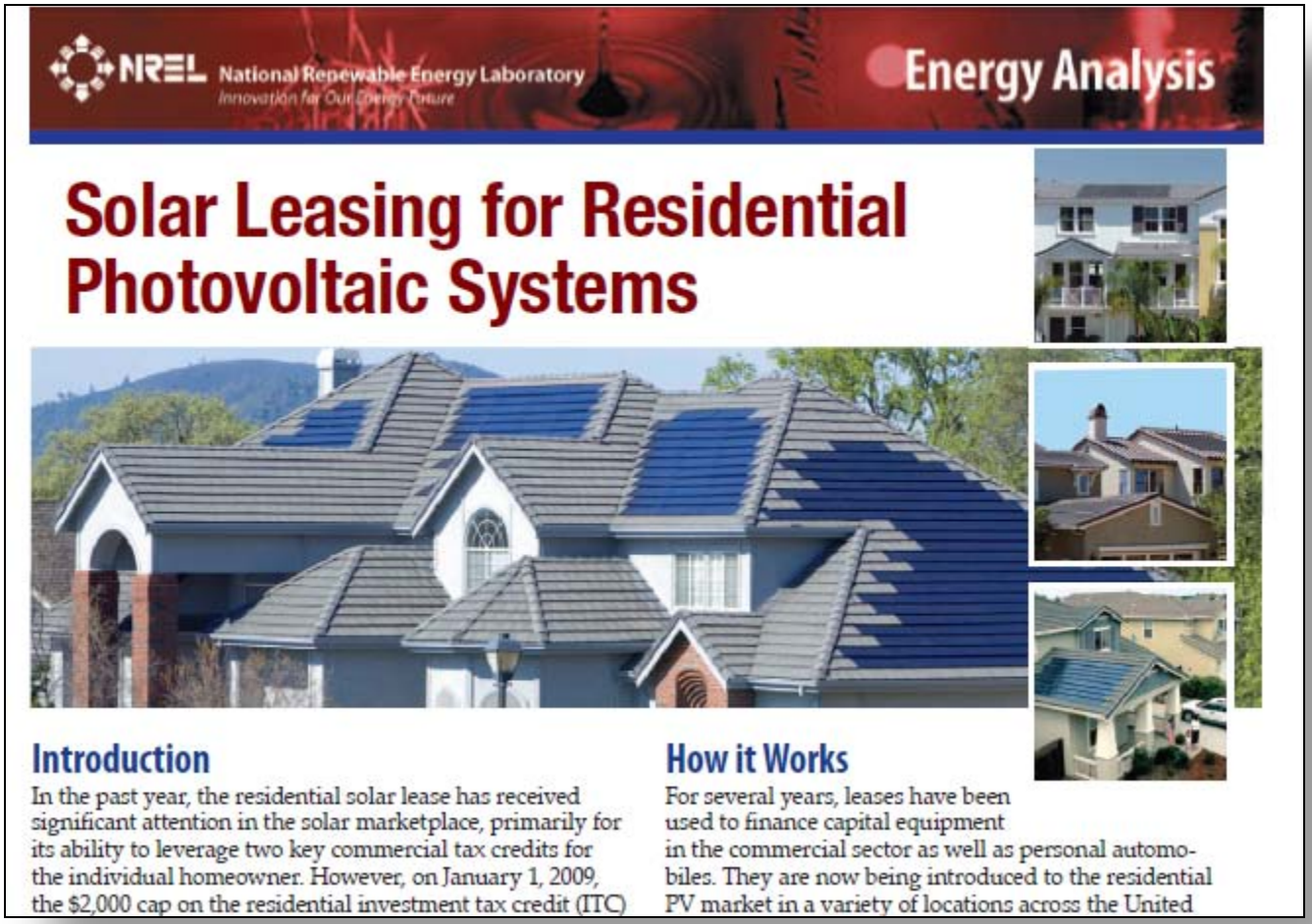
LBNL Report Conclusions

- CA PV homes sold for more than non-PV homes
- Average premiums were ~$5.5 per Watt
- Existing home premiums were even higher, and new home premiums were lower
- New vs. existing premiums may be partly explained by net installed costs, but also related to varying buyer/seller motivations (e.g., sales velocity)

Do Photovoltaic Energy Systems Increase Home Values?

- Residential PV Market Summary
- There Are Still Significant Market Barriers
- Previous Literature On Impacts To Home Values
- LBNL Research Findings
- **Where Do Stakeholders Go From Here?**
- Questions?

Residential Solar Leasing Allows Consumers To Pay Very Little Yet Have A PV System On Their Home



NREL National Renewable Energy Laboratory
Innovation for Our Energy Future

Energy Analysis

Solar Leasing for Residential Photovoltaic Systems

Introduction

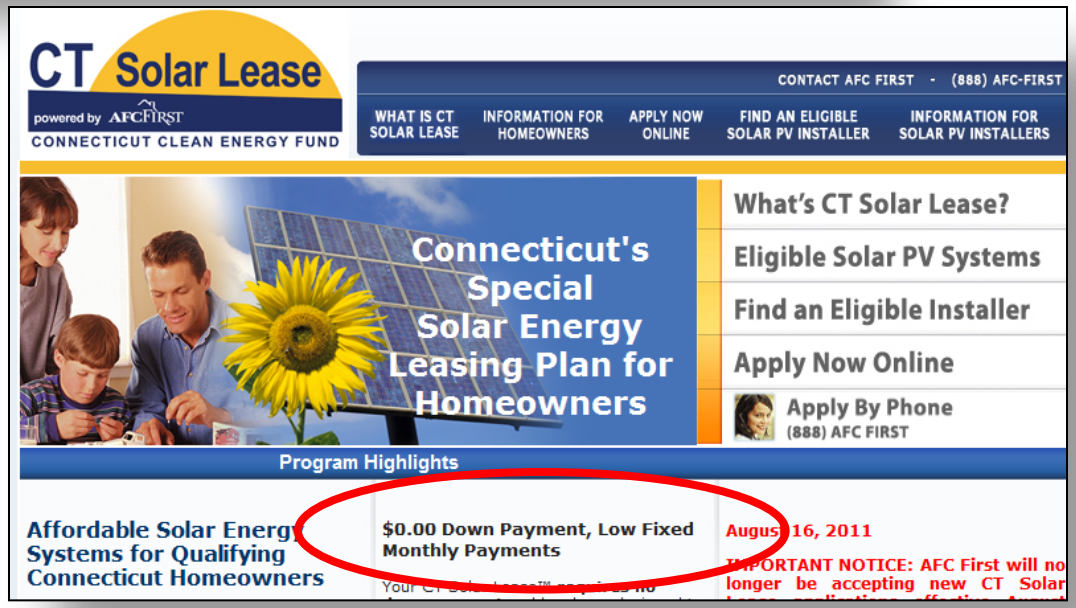
In the past year, the residential solar lease has received significant attention in the solar marketplace, primarily for its ability to leverage two key commercial tax credits for the individual homeowner. However, on January 1, 2009, the $2,000 cap on the residential investment tax credit (ITC)

How it Works

For several years, leases have been used to finance capital equipment in the commercial sector as well as personal automobiles. They are now being introduced to the residential PV market in a variety of locations across the United

Source: National Renewable Energy Laboratory, www.nrel.gov/docs/fy09osti/43572.pdf

Residential Solar Leasing

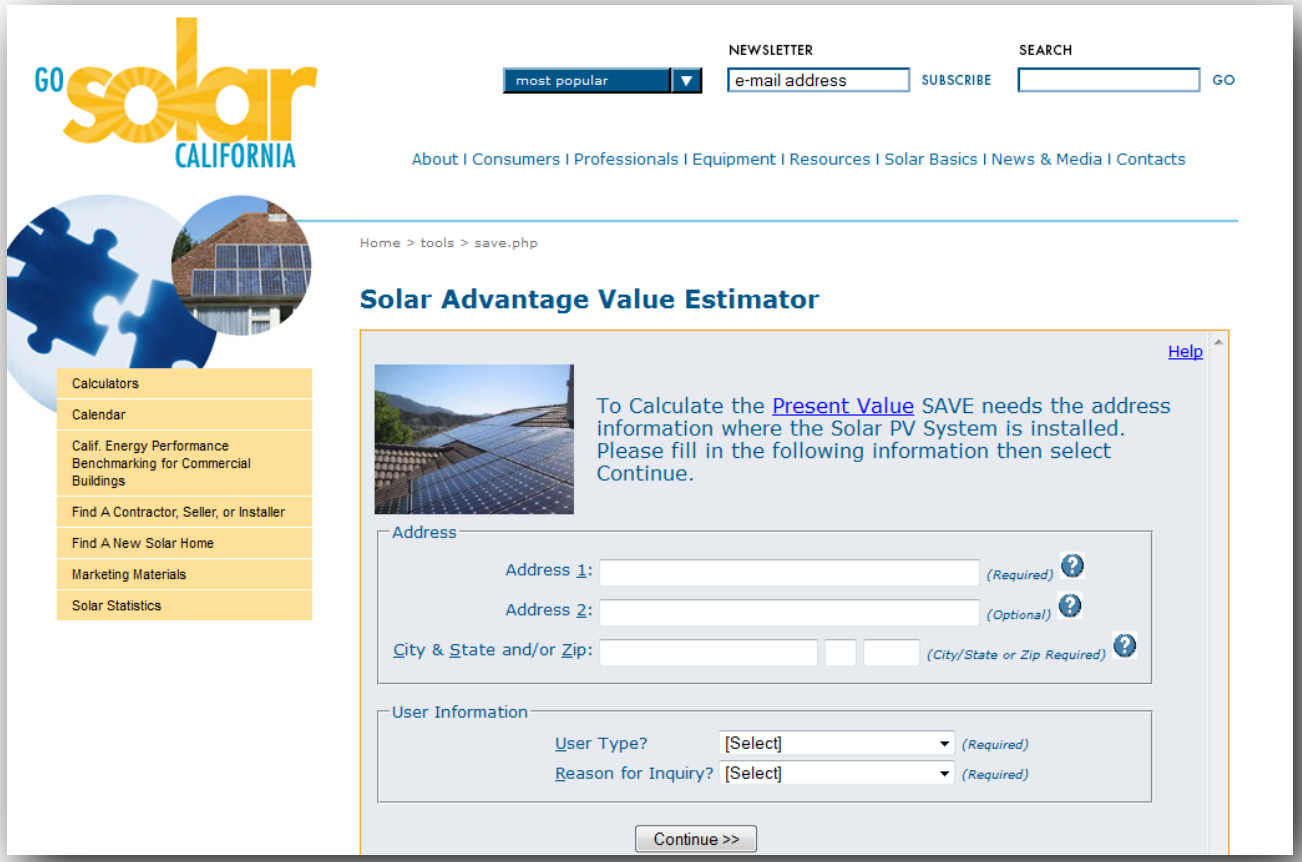


For Homeowners Who Want to Own A PV System Low-Interest Loan Options Are Often Available

Database of
State
Incentives for
Renewable
Energy

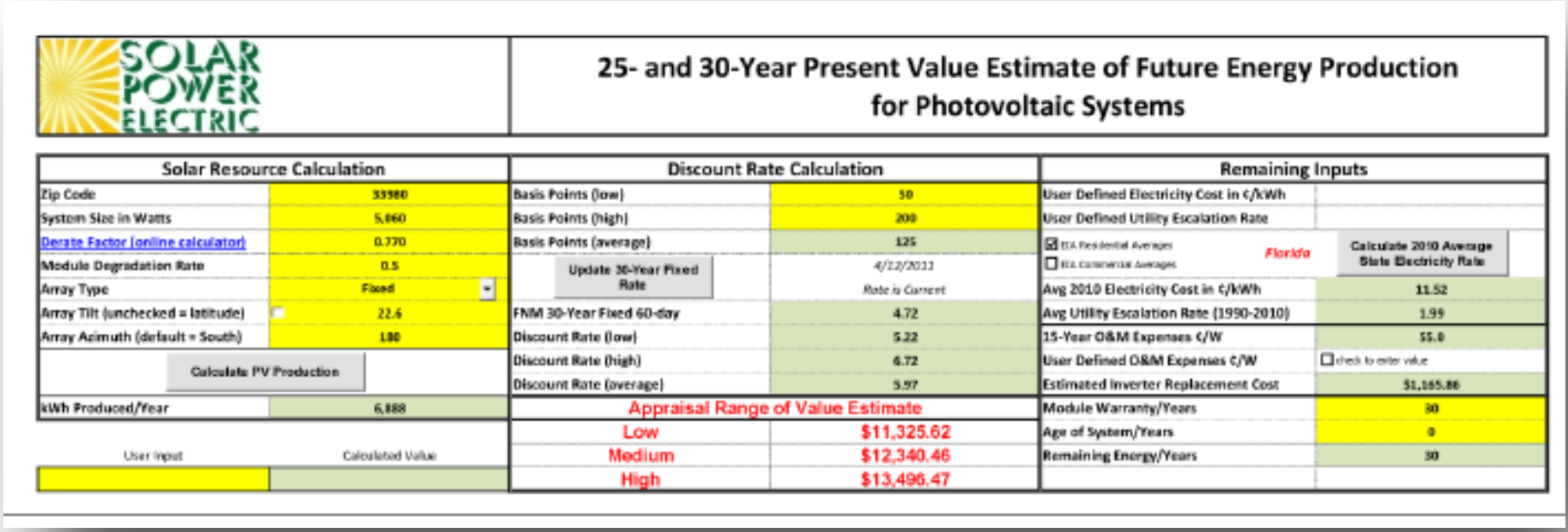
www.dsireusa.org

For California Homeowners Who Own A PV System Or Are Considering It, A Valuation Tool Is Available



http://www.gosolarcalifornia.org/tools/save.php

A National PV Valuation Tool Will Be Available Soon



SOLAR POWER ELECTRIC

25- and 30-Year Present Value Estimate of Future Energy Production for Photovoltaic Systems

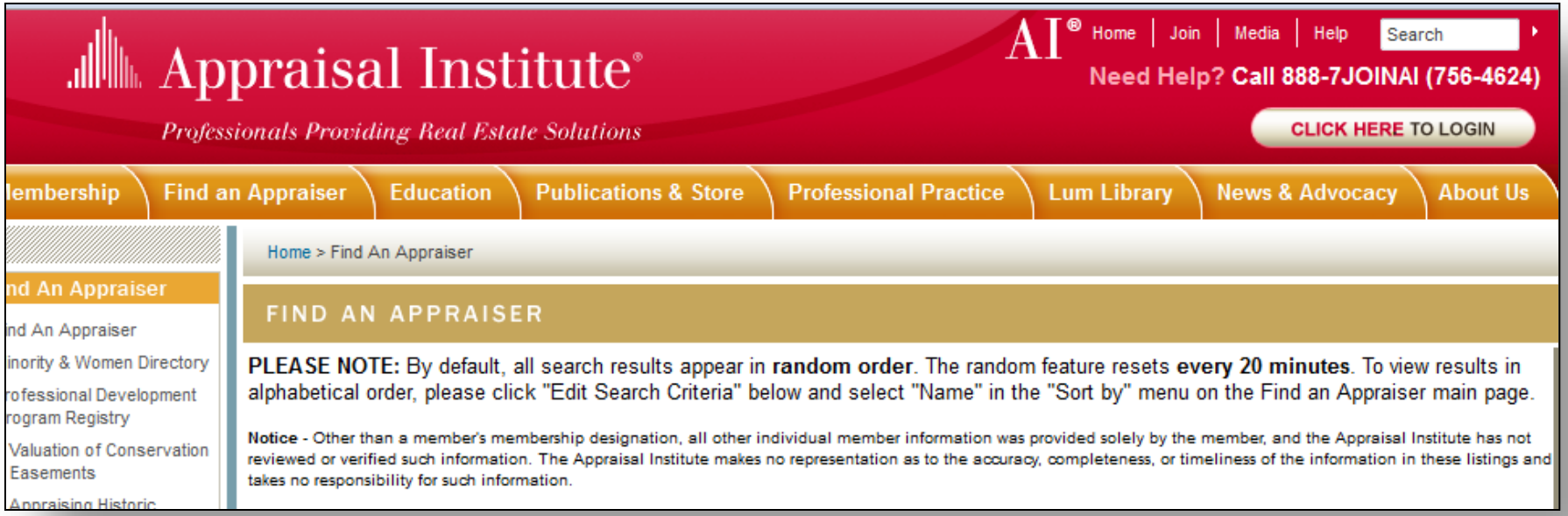
Solar Resource Calculation		Discount Rate Calculation		Remaining Inputs	
Zip Code	33980	Basis Points (low)	50	User Defined Electricity Cost in ¢/kWh	
System Size in Watts	5,060	Basis Points (high)	200	User Defined Utility Escalation Rate	
Derate Factor (online calculator)	0.770	Basis Points (average)	125	☑ EIA Residential Averages ☐ EIA Commercial Averages — Florida	Calculate 2010 Average State Electricity Rate
Module Degradation Rate	0.5	Update 30-Year Fixed Rate	4/22/2011		
Array Type	Fixed		Rate is Current	Avg 2010 Electricity Cost in ¢/kWh	11.52
Array Tilt (unchecked = latitude)	22.6	FNM 30-Year Fixed 60-day	4.72	Avg Utility Escalation Rate (1990-2010)	1.99
Array Azimuth (default = South)	180	Discount Rate (low)	5.22	15-Year O&M Expenses ¢/W	55.0
Calculate PV Production		Discount Rate (high)	6.72	User Defined O&M Expenses ¢/W	☐ check to enter value
		Discount Rate (average)	5.97	Estimated Inverter Replacement Cost	$1,185.86
kWh Produced/Year	6,888	Appraisal Range of Value Estimate		Module Warranty/Years	30
		Low	$11,325.62	Age of System/Years	0
User Input	Calculated Value	Medium	$12,340.46	Remaining Energy/Years	30
		High	$13,496.47		

www.spefl.com and http://www.sandia.gov/pv

Appraisal Institute Has A Variety Of Courses On How To Analyze The Value of "Going Green"

www.appraisalinstitute.org

Therefore Finding A Local Appraiser With Experience In Valuing Green Building and Energy Efficiency Features Is Easier



www.appraisalinstitute.org

Conclusions

- PV Costs are coming down
- Installations are increasing but there are still barriers
- Perceived price and ROI are important
- New data suggests PV home selling price premiums near net installed costs
- Options are emerging to pay $0 down, and finance at a low interest rate.
- New tools are available to estimate selling price based on energy savings
- Growing number of appraisers with experience are available

Do Photovoltaic Energy Systems Increase Home Values?

- Residential PV Market Summary
- There Are Still Significant Market Barriers
- Previous Literature On Impacts To Home Values
- LBNL Research Findings
- Where Do Stakeholders Go From Here?
- **Questions?**

Questions?

Ben Hoen
Lawrence Berkeley National Laboratory
845-758-1896, bhoen@lbl.gov

Link to report, 2-page summary, and presentation

http://eetd.lbl.gov/ea/emp/re-pubs.html

Citations

Barbose, G., Darghouth, N. and Wiser, R. (2010) Tracking the Sun III: The Installed Cost of Photovoltaics in the U.S. From 1998-2009. Lawrence Berkeley National Laboratory, Berkeley, CA. December 2010. 54 pages. LBNL-4121E.

Dastrop, S., Zivin, J. G., Costa, D. L. and Kahn, M. E. (2011) Understanding the Solar Home Price Premium: Electricity Generation and "Green" Social Status. NBER Working Paper Series. Prepared for National Bureau of Economic Research, Cambridge, MA. July 2011. 30 pages. Working Paper 17200.

Farhar, B. and Coburn, T. (2008) A New Market Paradigm for Zero-Energy Homes: A Comparative Case Study. *Environment: Science and Policy for Sustainable Development* 50(1): 18-32.

Hoen, B., Cappers, P., Wiser, R. and Thayer, M. (2011) An Analysis of the Effects of Photovoltaic Energy Systems on Residential Selling Prices in California. Lawrence Berkeley National Laboratory, Berkeley, CA. April, 2011. 46 pages. LBNL-4476E.

Johnson, R. C. and Kaserman, D. L. (1983) Housing Market Capitalization of Energy-Saving Durable Good Investments. *Economic Inquiry.* 21: 374 - 386.

National Renewable Energy Laboratory (NREL) (2009) Solar Leasing for Residential PV Systems. Golden, CO. 6 pages. NREL/FS-6A2-43572.

Nevin, R. and Watson, G. (1998) Evidence of Rational Market Values for Home Energy Efficiency. *The Appraisal Journal.* 68: 401-409.

Solar Energy Industries Association (SEIA) and GTM Research (GTM) (2011) U.S. Solar Market Insight - 2010 Year in Review. GTM Research (GTM) in Boston MA. Prepared for Solar Energy Industries Association (SEIA), Washington, DC.

SolarTech (2011) Solar PV Adoption Consumer Attitudes: Study and Recommendations for Marketing to Residential Consumers. Prepared for SolarTech, San Jose, CA. April 2, 2011.